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Research Paper

Utilization of Carrot Peel as a Natural Dye Using the Maceration Extraction Method

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***ABSTRACT**: Carrot peel (Daucus carota L.) is an underutilized by-product of carrot processing that is commonly discarded as household and agricultural waste, although it contains pigment-related bioactive compounds with potential application as natural colorants. This study focused on the extraction and evaluation of anthocyanin-containing pigment compounds from carrot peel using the maceration method and assessed their potential as natural dyes for textile substrates. Ethanol was selected as the extraction solvent due to its neutral character and ability to dissolve various plant pigment compounds without significantly altering the chemical stability of the extract. The maceration process was conducted using ethanol concentrations of 40% - 96%. The quality of the extract was evaluated based on absorbance, pH, yield, measured anthocyanin content, and dyeing performance on satin and calico fabrics. The results indicated that ethanol concentration influenced extract quality. Among all variations tested, the extract obtained using 96% ethanol exhibited the most favorable properties, with the highest absorbance value of 0.41075, the highest measured anthocyanin content of 61.73 mg/L, and a pH of 5.02. These results indicate that 96% ethanol produced a more concentrated pigment extract with strong color intensity and suitable acidity for natural dye applications. The dyeing tests conducted on satin and calico fabrics showed that the extract prepared with 96% ethanol produced the most visually appealing color results and received the highest preference scores from respondents.*

***Keywords:** Carrot peel extract, Natural dye, Maceration method, Ethanol concentration, Textile coloration, Anthocyanin*

1. INTRODUCTION

Natural dyes derived from plant materials have gained increasing attention due to their environmental friendliness, biodegradability, and lower toxicity compared with synthetic dyes, which may contain hazardous or carcinogenic compounds. The growing demand for safer and more sustainable colorants has encouraged the exploration of agricultural by-products as alternative sources of natural dyes. One potential raw material is carrot peel (Daucus carota L.), which is commonly discarded during household and food-processing activities. The utilization of carrot peel as a natural dye source provides an opportunity to reduce organic waste while increasing the added value of plant-based residues.

Carrot peel contains several pigment-related bioactive compounds that may contribute to its color characteristics, including carotenoids, phenolic compounds, and anthocyanin-associated pigments. Although carrot tissues are generally recognized for their carotenoid content, particularly β-carotene, the present study specifically focuses on the extraction and evaluation of anthocyanin-containing pigment compounds as the main analytical pigment parameter. Anthocyanins are flavonoid pigments that can produce red, purple, or bluish coloration depending on pH and solvent conditions. These compounds are also known not only for their coloring properties, but also for their antioxidant activity, which helps neutralize free radicals associated with degenerative diseases [1].

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The extraction of anthocyanin-containing pigments from plant matrices is strongly influenced by solvent type and solvent concentration. Ethanol is widely used in natural pigment extraction because it is relatively safe, less toxic, readily available, and capable of dissolving various polar and semi-polar bioactive compounds. In addition, ethanol-water mixtures can improve solvent penetration into plant tissues and facilitate the release of pigment compounds from cellular structures. The polarity of the extraction solvent plays an important role in determining pigment recovery, extract intensity, and color stability [2], [3], [4], [5].

High-purity ethanol has been reported to produce dye extracts with better quality and stability than lower ethanol concentrations. Studies on various pigment-rich plants, including Hibiscus sabdariffa and Clitoria ternatea, have shown that ethanol concentrations around 95% can enhance color depth and reduce extraction time [2], [6]. In addition, research on Beta vulgaris and other pigment rich plants confirms that 95% ethanol yields significantly higher anthocyanin levels, which are essential for vibrant and durable textile dyes [7]. Comparative results reveal that solvents with lower ethanol concentrations, such as 70% or aqueous extracts, tend to produce dyes with weaker intensity and poorer stability, highlighting the superiority of high-purity ethanol in pigment extraction [8].

Maceration is one of the simplest and most commonly applied extraction methods for plant-based pigments. This method involves soaking plant materials in a suitable solvent under mild conditions, allowing pigment compounds to diffuse from the solid matrix into the solvent [9]. Compared with high-temperature extraction techniques, maceration is advantageous because it can minimize thermal degradation of heat-sensitive compounds, including anthocyanin-related pigments. However, the effectiveness of maceration depends on several factors, such as solvent concentration, extraction duration, solid-to-solvent ratio, particle size, and temperature [10].

Other studies corroborate these findings, noting that the extraction time can also influence the sensory attributes of the final dye product. Hamid and Munaima (2017) conducted experiments involving dyeing processes with pigments extracted from dragon fruit peel. They noted that optimizing extraction time significantly affected the dye's uptake on fabric substrates, leading to improved vibrancy and consistency in color application [11]. These observations further highlight the imperative nature of extraction time as a critical parameter in the dye extraction process.

Previous studies have reported the use of plant-based materials as natural dye sources, but the utilization of carrot peel waste as an anthocyanin-containing dye extract for textile substrates remains limited. In particular, the effect of ethanol concentration on the physicochemical properties and dyeing performance of carrot peel extract has not been sufficiently discussed. Therefore, this study aims to evaluate the influence of ethanol concentration on the quality of carrot peel extract obtained by maceration. The extract quality was assessed based on absorbance, pH, extraction yield, anthocyanin content, and visual dyeing performance on satin and calico fabrics. This study is expected to support the valorization of carrot peel waste as a sustainable natural dye source while providing information on the role of ethanol concentration in improving pigment extraction efficiency.

2. RESEARCH METHOD

2.1. Materials

The raw material used in this study was red carrot peel (Daucus carota L.). A total of 250 g of fresh carrot peel was prepared as the initial raw material. Ethanol solutions with concentrations of 40%, 50%, 60%, 70%, 80%, and 96% were used as extraction solvents. Alum was used as the mordanting agent, while lime juice solution was used as the post-mordant. Satin and calico fabrics were used as textile substrates for dyeing evaluation.

2.2 Preparation of Raw Material

Fresh red carrot peel was first washed thoroughly with clean water to remove adhering dirt and impurities. The cleaned carrot peel was then cut into small pieces to increase the surface area and improve solvent penetration during extraction. The prepared carrot peel was dried at room temperature for 3 h prior to the maceration process.

2.3 Maceration Extraction Procedure

The maceration extraction was carried out using six ethanol concentrations, namely 40%, 50%, 60%, 70%, 80%, and 96%. For each treatment, 50 g of prepared red carrot peel was weighed and placed into a maceration vessel. Then, 250 mL of ethanol solution at the designated concentration was added to the sample. Therefore, the solid-to-solvent ratio used in this study was 1:5 (w/v). The mixture was soaked for 3 days at room temperature. During maceration, the mixture was stirred periodically to improve contact between the solvent and the plant material and to facilitate the diffusion of pigment compounds into the solvent. After the maceration process was completed, the extract was filtered using muslin cloth to separate the liquid extract from the remaining solid residue. Each ethanol concentration treatment was conducted as a single experimental run; therefore, the resulting absorbance, pH, yield, and anthocyanin content values were interpreted descriptively. This replication condition was explicitly stated to clarify the experimental design and the scope of data interpretation.

2.4 Concentration of Extract

Each filtrate obtained from the maceration process was concentrated using a rotary evaporator at 90 °C for 1 h to remove part of the solvent. The concentrated extract was then further evaporated using a hot plate at 100 °C for 1 h to obtain a thicker carrot peel extract. The same concentration conditions were applied to all treatments to ensure comparability among different ethanol concentrations.

2.5 Absorbance, Wavelength, and pH Analysis

The absorbance and maximum wavelength of carrot peel extracts were measured using a UV–Visible spectrophotometer (Shimadzu UV-1800, Shimadzu Corporation, Kyoto, Japan) operated at a wavelength range of 190–1100 nm with a 1 cm quartz cuvette. The extract was scanned to determine the maximum wavelength, and absorbance was measured at the selected wavelength using the corresponding ethanol solution as the blank. The absorbance value was used as an indicator of pigment intensity. The pH of each concentrated extract was measured using a calibrated digital pH meter.

2.6 Determination of Extraction Yield

The extraction yield was calculated by comparing the weight of the extract obtained after concentration with the initial weight of the carrot peel sample. The extraction yield was calculated using the following equation :

$$Yield\ (\%) = \frac{Weight\ of\ Extract}{Weight\ of\ Sample} \text{ x } 100\% \quad \text{..... (1)}$$

where the weight of extract refers to the mass of concentrated carrot peel extract, and the weight of sample refers to the initial mass of carrot peel used in each treatment, which was 50 g.

2.7 Determination of Anthocyanin Content

The anthocyanin concentration was expressed as cyanidin-3-glucoside equivalent. This value was used as a complementary indicator of ethanol-soluble phenolic pigments and should not be interpreted as the

dominant pigment fraction in carrot peel, since carrot peel coloration is mainly associated with carotenoids, particularly β-carotene. The anthocyanin content was calculated using the following equation [11] :

$$mg/_L = \frac{A \text{ x } MW \text{ x } DF \text{ x } 1000}{\varepsilon \text{ x } L} \quad \text{..... (2)}$$

where A is the measured absorbance, MW is the molecular weight of cyanidin-3-glucoside, equal to 449.2 g/mol, DF is the dilution factor, ε is the molar absorptivity of cyanidin-3-glucoside, equal to 26.900 L/mol·cm, and L is the cuvette path length, equal to 1 cm.

2.8 Dyeing Procedure

Satin and calico fabrics were cut into pieces with dimensions of 8 cm × 5 cm. Alum solution was prepared at a concentration of 10 g/L by dissolving alum in water until completely dissolved. Each fabric sample was immersed in the alum solution as a pre-mordanting treatment. After mordanting, the fabrics were washed thoroughly with water and dried before the dyeing process.

The mordanted satin and calico fabrics were immersed in carrot peel dye extract prepared from each ethanol concentration. The dyeing process was carried out by boiling the fabrics in the dye solution for 10 min. After dyeing, the fabrics were removed from the dye bath and dried at room temperature.

After the dyeing process, the dyed fabrics were immersed in lime juice solution as a post-mordanting treatment. The fabrics were soaked in the lime mordant solution for 15 min. After post-mordanting, the fabrics were rinsed with water and dried at room temperature. This treatment was conducted to improve color fixation and visual color appearance on the fabric surface.

2.9 Hedonic Test

A hedonic test was conducted to evaluate consumer acceptance of the dyed satin and calico fabrics. The assessment focused on the visual color appearance of fabrics dyed using carrot peel extracts obtained from different ethanol concentrations. Panelists evaluated the attractiveness of the fabric color using a four-point hedonic scale, where 1 = not attractive, 2 = less attractive, 3 = attractive, and 4 = very attractive.

The panelists compared the color produced on satin and calico fabrics based on the ethanol concentration used during extraction. The hedonic test was performed to determine the most preferred dyeing result and to assess the potential acceptance of carrot peel extract as a natural dye for textile applications.

The hedonic test interval estimates typically use this following formula [13] :

$$P_{min} = \bar{P} - Z\sqrt{\left(\frac{\bar{P}(1-\bar{P})}{n}\right)} \quad \text{..... (3)}$$

$$P_{max} = \bar{P} + Z\sqrt{\left(\frac{\bar{P}(1-\bar{P})}{n}\right)} \quad \text{..... (4)}$$

Where,

$\bar{P}$ = proportion of panelists who gave a certain score

n = number of panelists (n = 28),

Z = Z-score based on confidence level (usually 95% confidence → Z = 1.96).

2.10 Experimental Limitation

The physicochemical analyses, including absorbance, pH, extraction yield, and anthocyanin content, were conducted for each ethanol concentration treatment and interpreted descriptively based on comparative trends among treatments. Since independent experimental replications were not performed for these physicochemical measurements, inferential statistical analysis such as ANOVA and post hoc tests could not be applied. Therefore, the differences among ethanol concentration treatments were discussed as descriptive

trends rather than statistically significant differences. For the hedonic evaluation, 28 panelists were involved, and the data were analyzed based on panelist preference distribution and interval estimation. The hedonic test was used to describe consumer acceptance of the dyed satin and calico fabrics.

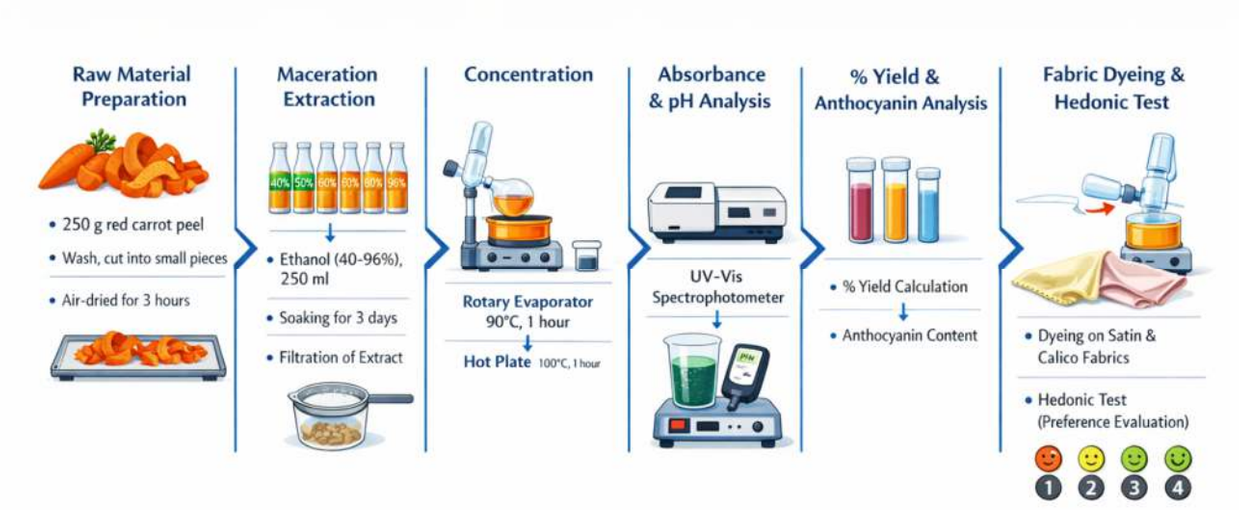

Figure 1. Graphical Abstract : Utilization of Carrot Peel as a Natural Dye Using the Maceration Extraction Method

3. RESULT AND DISCUSSION

Carrot peel extract (Daucus carota) was prepared using the maceration technique. This method was selected because it is a cold extraction process in which the plant material is soaked in a solvent at room temperature, thus preventing the degradation or breakdown of natural compounds. Maceration also offers several benefits, including simple operational steps, the use of basic equipment, relatively low processing costs, and the ability to preserve thermolabile constituents from heat-induced damage. In this study, carrot peel (*Daucus carota*) was extracted using ethanol as the solvent. Ethanol was selected because it is a universal solvent relatively inexpensive, easily accessible, highly selective, and capable of extracting a wide range of compounds from non polar to polar. In addition, ethanol is considered safe and non-toxic, making it suitable for extracting natural materials. The extraction results of carrot peel are shown in Table 1.

Table 1. Carrot Peel Extract After Maceration

Sample	Solvent Concentration (%)	Sample Weight (gram)	Absorbance	pH	Yield (%)	Anthocyanin (mg/L)
1	96	50	0.41075	5.02	71.03	61.73
2	80	50	0.16525	5.04	72.93	24.83
3	70	50	0.15431	5.08	74.82	23.19
4	60	50	0.15236	5.09	75.77	22.90
5	50	50	0.14383	5.10	77.35	21.16
6	40	50	0.11420	5.12	78.93	17.16

Table 2. Minimum and Maximum Absorbance Values of Carrot Peel Extract Color on Two Types of Fabrics

Ethanol Concentration	Satin Fabric		Calico Fabric	
	Pmin	Pmax	Pmin	Pmax
96%	0.99	1.22	1.15	1.56
80%	1.24	1.61	1.15	1.56
70%	1.66	2.12	1.79	2.06
60%	1.73	2.19	1.85	2.22
50%	1.85	2.43	1.75	2.17
40%	1.92	2.50	1.82	2.24

3.1. Solvent Concentration Effect on Absorbance Value

Absorbance is a crucial analytical parameter that quantifies the amount of light absorbed by a material at a specific wavelength, resulting in the observed color of the extract [14]. Ideal absorbance values typically fall within the range of 0.2 to 0.8, where higher values indicate an increased concentration of pigments isolated from the material, producing more intense colors. In studies focusing on carrot peel extracts, determining the optimal solvent concentration for extracting bioactive compounds is vital for maximizing pigment yield and enhancing functional properties. The effect of solvent concentration on absorbance value of carrot peel extract is shown in Figure 2.

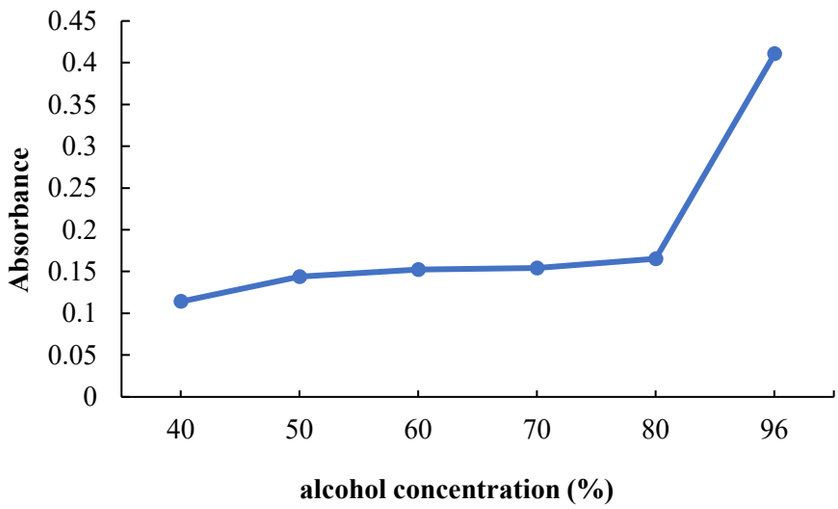

Figure 2. Absorbance Value Graph with Solvent Concentration

The results presented in Figure 2 show that the absorbance values of carrot peel extract increase as the solvent concentration rises, which in this study was varied at 40%, 50%, 60%, 70%, 80%, and 96%. This upward trend appears consistent and proportional: the 96% solvent concentration yielded the highest absorbance value (0.41075), while the 40% concentration produced the lowest absorbance (0.11420). This pattern demonstrates that solvent composition is a critical determinant of pigment extraction performance from carrot peel matrices. The reduction in water content (higher ethanol purity) strengthens the solvent's ability to dissolve hydrophobic target compounds. Such findings align with general principles of carotenoid extraction, in which solvents of lower polarity tend to enhance the solubility and desorption of pigments from plant tissue [15], [16].

Chemically, carotenoids, including β-carotene, which dominates in carrots, have long polyene chains and are highly hydrophobic. As a result, they are more effectively extracted using nonpolar or semi polar solvents and much less efficiently in aqueous environments. Increasing ethanol concentration from 40% to 96% effectively reduces the polarity of the mixture due to decreased water content, improving solvent solute compatibility and facilitating solvent diffusion into cellular matrices as well as pigment release into the liquid phase. These observations are consistent with laboratory studies showing that nonpolar solvents such as heptane extract carotenoids more efficiently than ethanol (moderately effective), while water is ineffective due to its high polarity. Process-based studies on carrots further indicate that carotenoid extraction efficiency depends not only on solvent polarity but also on pretreatment conditions, temperature, and extraction time.

In research involving carrots and pumpkins, solvent mixtures incorporating nonpolar components such as acetone : hexane were reported to yield higher total carotenoid content than ethanol alone, emphasizing the importance of nonpolar fractions in extracting lipophilic pigments effectively. Consequently, the rising absorbance values from 40% to 96% ethanol in this study represent a logical progression toward the upper performance limit achievable with aqueous ethanol. Although in many optimization frameworks, purely nonpolar or binary solvent systems (hexane or acetone : hexane mixtures) may exceed the performance of 96% ethanol, the findings here remain scientifically consistent: ethanol at 96% serves as the optimal condition within the range of aqueous ethanol tested, while theoretically, even greater extraction efficiency could be reached with less polar solvent systems [17].

3.2. The Effect of Solvent Concentration on pH Value

pH is a measure of acidity used to express how acidic or basic a solution is. The pH value indicates the concentration of hydrogen ions (H^+) and can be measured using a pH meter for precise determination. Anthocyanins, which are water-soluble flavonoid pigments, exhibit different colors depending on the pH conditions, as their molecular structure changes in response to proton concentration. Variations in pH can shift their appearance from red in acidic environments to purple or blue under less acidic or neutral conditions, reflecting their pH-dependent structural transformation [18]. The effect of solvent concentration on pH value of carrot peel extract is shown in Figure 3.

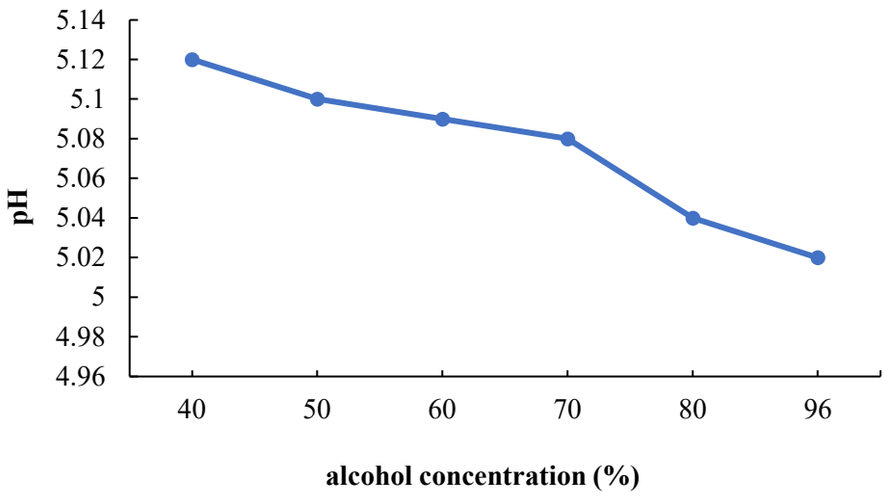

Figure 3. pH Value Graph with Solvent Concentration

From Figure 3, it can be observed that the solvent concentration of 96% produces the lowest pH value, which is 5.02, while the 40% concentration produces the highest pH value, 5.12. This pattern occurs because lower solvent concentrations contain a higher proportion of water compared to the 96% solvent. Since water

generally has a neutral pH, its greater presence shifts the mixture toward a slightly higher pH. The measurement of pH itself reflects the concentration of hydrogen ions in a solution and is typically determined using a pH meter for accurate results. As the amount of water increases in the solvent mixture, the overall acidity decreases, causing an observable elevation in pH values at lower solvent concentrations [19].

The change in solution acidity also directly affects the color intensity of anthocyanin-containing extracts. Anthocyanins are known to undergo structural transformations in response to pH variations, which results in distinct color changes. At lower pH levels, anthocyanins predominantly exist in their flavylium cation form, which displays more intense red hues, making the extract appear darker and more vibrant. As the pH increases due to higher water content, these pigments shift toward less intensely colored forms, explaining why color intensity decreases at higher pH values. Thus, the variations observed in pH across different solvent concentrations are not only influenced by water content but also play a significant role in determining the visual characteristics of the extract [16].

3.3. The Effect of Solvent Concentration on Yield and Pigment-Related Parameters

Carrot peel is primarily characterized by carotenoid pigments, especially β-carotene, which contribute to its orange coloration. Nevertheless, anthocyanin content was measured in this study as an additional pigment-related parameter because ethanol-water mixtures can extract certain phenolic pigment compounds. Therefore, the measured anthocyanin value should be interpreted as a complementary indicator of ethanol-soluble pigment-associated compounds rather than as the principal determinant of carrot peel color. In carrot tissues, anthocyanin levels may reach up to 1750 mg/kg. The purity of ethanol plays a significant role in the extraction efficiency of anthocyanin pigments, a decrease in ethanol purity increases solvent polarity because of higher water content, which in turn reduces the amount of pigment extracted. This trend is consistent with modern extraction studies showing that anthocyanins, as water-soluble flavonoids, require an optimal balance of solvent polarity, where excessively polar mixtures decrease extraction efficiency due to reduced solubility of anthocyanin structures in highly aqueous systems [20].

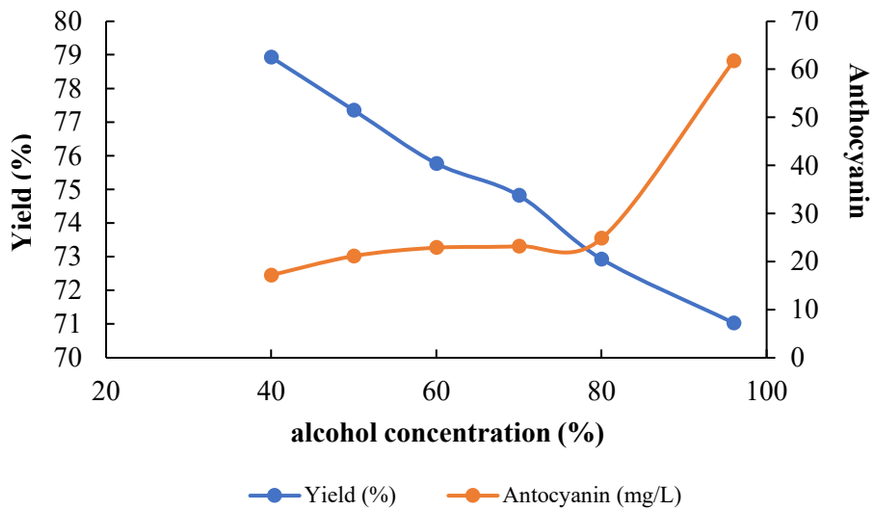

Figure 4. Anthocyanin Value and Yield Graph with Solvent Concentration

Figure 4 illustrates that increasing ethanol concentration increased the measured anthocyanin content of carrot peel extract, from 17.16 mg/L at 40% ethanol to 61.73 mg/L at 96% ethanol. This result indicates that higher ethanol concentration improved the recovery of ethanol-soluble pigment-related compounds. Higher ethanol concentration lowers solvent polarity, enhancing the ability of ethanol to penetrate plant

matrices and solubilize anthocyanins more effectively. Recent findings support the superiority ethanol based systems for anthocyanin extraction; studies report that anhydrous or high purity ethanol significantly improves anthocyanin recovery compared to diluted ethanol or water-rich solvents. Similar results were also documented in extraction of anthocyanins from jambolan fruit using ethanol dominant solvent systems, where higher ethanol fractions improved pigment yield and color stability. These findings align with earlier and current research trends, confirming that higher ethanol concentrations produce better anthocyanin extraction outcomes [21], [22].

Extract yield represents the ratio between the mass of extract obtained and the initial sample weight. An extract is generally considered effective when its yield exceeds 10%. As shown in Figure 4, the extract yield decreases as ethanol concentration increases. The yield values ranged from 78.93% at 40% ethanol to 71.03% at 96% ethanol. This inverse trend occurs because ethanol has a lower boiling point than water; therefore, higher ethanol fractions evaporate more readily during solvent removal, resulting in a smaller final extract mass. The reduction in extract volume at higher ethanol concentrations reflects the selective extraction of anthocyanins and fewer non-pigment components, producing a more concentrated colorant.

3.4. Hedonic Test Results on Satin and Calico Fabrics

The extract obtained from the carrot peel extraction was applied to satin fabric and calico fabric to evaluate its performance as a natural dye. Both fabric types were able to absorb the pigment-rich extract containing anthocyanin-associated compounds, although with different visual and textural outcomes due to their distinct fiber characteristics. Satin, which has a smoother and more tightly woven surface, exhibited a more vibrant and glossy coloration, allowing the pigment to spread evenly across the fabric. In contrast, calico, being a more loosely woven and absorbent cotton fabric, displayed a softer and more muted color appearance, as its natural fiber structure readily absorbed the dye deeper into the fabric matrix.

(a) (b)

Figure 5. Dyeing Results on Satin (a) and Calico Fabrics (b)

Following the dyeing process, a hedonic test was conducted to assess consumer acceptance of the dyed fabrics. A total of 28 panelists, consisting of university students and members of the general public, evaluated the color attractiveness of both satin and calico fabrics dyed using extracts prepared with different solvent concentrations. Using a four-point scale—1 = not attractive, 2 = less attractive, 3 = attractive, and 4 = very attractive—the panelists compared and scored the visual appeal of the resulting colors.

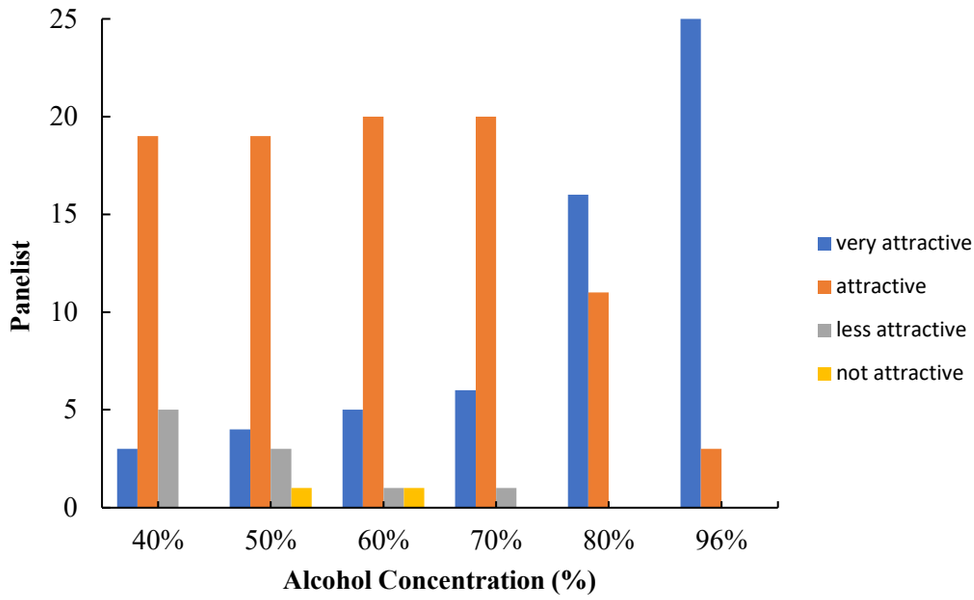

Figure 6. Hedonic Test Graph of Color Appearance on Satin Fabric

Based on the hedonic test results shown in Figure 6, respondents demonstrated the highest preference for satin fabric dyed with the 96% solvent concentration, with 25 panelists indicating it as very attractive. Conversely, the least preferred coloration was observed at the 40% concentration, selected by only 5 panelists. Hedonic interval estimation using the Pmin and Pmax method produced the following interval estimates: 96% concentration $P(0.99) \leq \mu \geq P(1.22)$; 80% concentration $P(1.24) \leq \mu \geq P(1.61)$; 70% concentration $P(1.66) \leq \mu \geq P(2.12)$; 60% concentration $P(1.73) \leq \mu \geq P(2.19)$; 50% concentration $P(1.85) \leq \mu \geq P(2.43)$; and 40% concentration $P(1.92) \leq \mu \geq P(2.50)$. These intervals indicate that lower P values correspond to stronger acceptance, confirming that the 96% concentration produced the most appealing color appearance on satin fabric.

Similarly, the hedonic test for calico fabric, as shown in Figure 7, revealed comparable trends. Respondents favored the appearance of calico fabric dyed with the 96% solvent concentration, with 19 panelists rating it as very attractive, while the 40% concentration was the least preferred, gaining only 2 panelist votes. The stronger preference for higher concentrations is attributed to the deeper and more intense color produced by more concentrated extracts, while lower concentrations yielded paler and less attractive shades. The corresponding Pmin and Pmax calculations for calico fabric were: 96% concentration $P(1.15) \leq \mu \geq P(1.56)$; 80% concentration $P(1.15) \leq \mu \geq P(1.56)$; 70% concentration $P(1.79) \leq \mu \geq P(2.06)$; 60% concentration $P(1.85) \leq \mu \geq P(2.22)$; 50% concentration $P(1.75) \leq \mu \geq P(2.17)$; and 40% concentration $P(1.82) \leq \mu \geq P(2.24)$. These values further confirm that higher solvent concentrations resulted in better color acceptance among panelists.

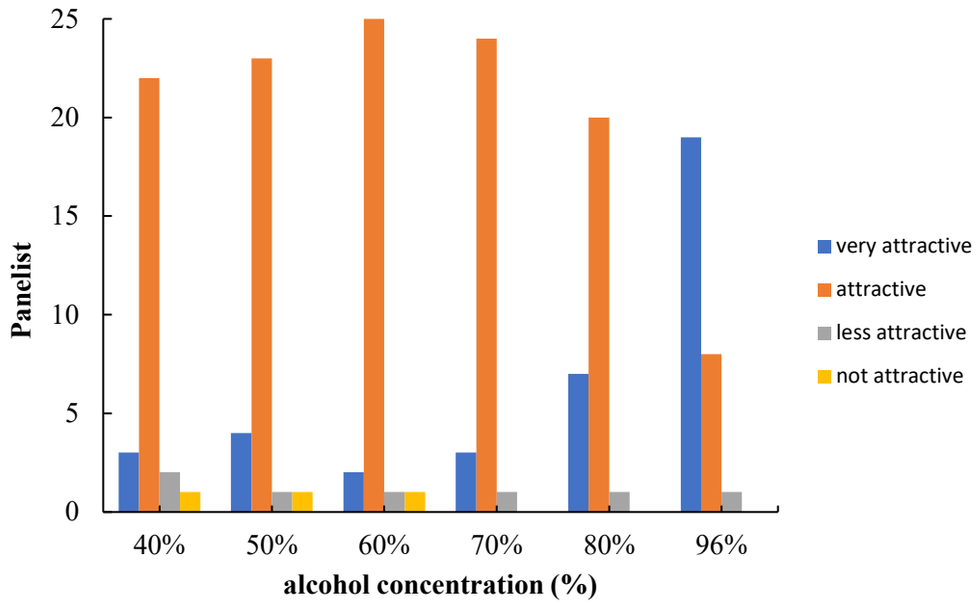

Figure 7. Hedonic Test Graph of Color Appearance on Calico Fabric

The assessment indicated that fabrics dyed using extracts obtained from higher ethanol concentrations, particularly 96%, received higher attractiveness ratings. This aligns with anthocyanin extraction research, which shows that higher-purity ethanol increases pigment concentration and color intensity, producing deeper and more stable hues [18].

Although the dyeing performance was evaluated through visual hedonic testing, instrumental color measurement and color fastness analysis were not conducted in this study. Therefore, the present findings should be considered as an initial evaluation of carrot peel extract as a natural dye. Future studies are recommended to include CIELab color measurement, washing fastness, rubbing fastness, and pigment stability tests to further confirm its applicability for textile dyeing.

4. CONCLUSION

Based on the results and discussion of this study, solvent concentration influenced the characteristics of the natural dye extracted from carrot peel, with higher solvent concentrations produce more optimal extraction performance. The optimum solvent concentration was found at 96%, yielding an absorbance of 0.41075, a pH value of 5.02, an extract yield of 71.03%, and an anthocyanin content of 61.7 mg/L. Furthermore, the hedonic test results indicated that panelists showed the highest preference for both satin and calico fabrics dyed using the 96% extract concentration.

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